

ORIGINAL ARTICLE / *Thoracic imaging*

# Pseudarthrosis of the cartilaginous part of the first rib is a common incidental finding on chest CT



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## KEYWORDS

First rib;  
Pseudarthrosis;  
Fracture;  
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## Abstract

**Purpose:** The cartilaginous parts of the first rib are usually articulating with sternal manubrium via a synchondrosis. With advancing age, there is progressive calcification of the rib cartilage. Pseudarthrosis of this calcified cartilage have been described in a study on anatomic specimen, but there are no systematically studies examining the anatomy of the cartilaginous parts of the first rib in vivo or using computed tomography (CT).

**Material and methods:** A retrospective study of 60 chest CT scans of patients without history of trauma was performed and 120 first ribs were examined. In all patients, the grade of calcifications of the first rib was determined (no calcifications/some calcifications/severe and at least on one side contiguous calcification of the cartilage) and the presence of pseudarthrosis was noted.

**Results:** Pseudarthrosis was found in 39/120 ribs (32.5%). The occurrence of pseudarthrosis was significantly more common in patients with severe calcifications (54%) in contrast to patients with no or minor calcifications (6.1%).

**Conclusions:** Pseudarthrosis of the first rib is a common finding in patients with severe calcifications. Radiologists should be aware of this frequent incidental finding, that should not be mistaken for pathology in CT imaging after trauma.

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The cartilaginous parts of the first rib are usually articulating with the sternal manubrium via a synchondrosis. With advancing age, there is a progressive calcification of these cartilaginous parts. This can lead to complete synostosis [1]. Fractures of the cartilaginous parts of the ribs have been described after trauma [2,3]. Computed tomography

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(CT) is now frequently used in patients with trauma and persistent pain at the upper thoracic aperture or the shoulder girdle. In our daily practice, we frequently noted the aspect of pseudarthrosis of the cartilaginous parts of the first rib in patients undergoing chest CT for non-traumatic reasons. In the case of CT scanning after trauma, a thorough knowledge of the normal anatomy and its variation is crucial for the reporting physician to distinguish pathology and variant anatomy. There is only one systematic study examining the prevalence of pseudarthrosis of the cartilaginous parts of the first rib using radiography of anatomical specimen [1]. To the best of our knowledge, there are no systematically studies examining the anatomy of the cartilaginous parts of the first rib and the occurrence of pseudarthrosis in vivo or using computed tomography. Therefore this small retrospective study was performed.

## Material and methods

This retrospective study was performed in accordance to the statute of the ethics committee of the affiliated University of Göttingen. The sample consisted of 60 chest CT scans performed in our department. These consisted of 50 consecutive scans between the 10th of december 2013 and the 10th of january 2014. For a more balanced age distribution, 10 additional scans of patients younger than 40 years from September through December 2013 were added. Patients were included if they were undergoing imaging for non-traumatic reasons (lung disease, suspected pulmonary embolism and malignant tumors). Patients with a recent history of trauma were not considered for evaluation. The sample consisted of 32 men and 28 women with a mean age of 61.7 years (range 21–93 years), i.e. 120 first ribs were evaluated. The same parameters were used in all patients (120 kV, 80 mAs, 1 mm slice thickness, automatic exposure control) on a 16 slice-scanner (Activion®, Toshiba Medical Systems, Tokio, Japan). Scans were acquired during breath hold in deep inspiration. The arms were positioned above the head. The primary data sets were examined using the departmental PACS (synedra view® 3.3.0.8 "EOS", Synedra, Innsbruck, Austria) by a single consultant radiologist (JG). In accordance to the proposed mechanism of progressive calcification with age, the calcifications were graded as followed: 0 = no calcifications, 1 = some calcifications and 2 = severe and at least on one side contiguous calcification of the whole cartilage with bridging of the first costosternal joint (Fig. 1). The presence of pseudarthrosis was noted.



**Figure 1.** Different grades of calcification of the cartilaginous part of the first rib. On the left, there is no calcification (grade 0). In the middle, minor calcification can be found on both sides, but there are no bridging calcifications (grade 1). On the right, there are severe and bridging calcifications with synostosis (grade 2).

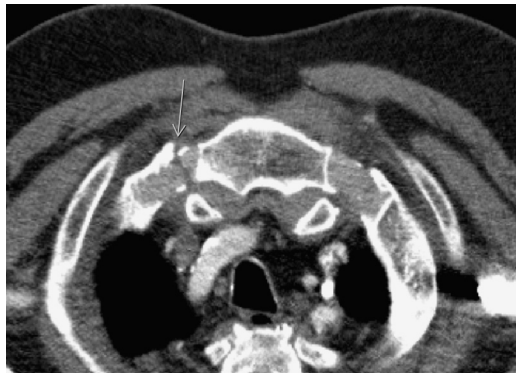
Usually the first rib articulates via a synchondrosis with the sternal manubrium. As described above with progressive calcifications, there may be synostosis at the sternocostal joint of the first rib or there may be a small remnant of non-calcified cartilage at the joint only [1]. The following morphological signs were registered as pseudarthrosis: joint-like structures with sclerotic margins and a visible joint space or complete clefts in the cartilaginous parts of the first rib lateral to the sternocostal joint and medial the bone-cartilage interface of the first rib. Secondary signs of fracture, like hematoma, dislocation were noted. Statistics were performed using a commercial available statistic software (Statistica, Version 5.5, Stat Soft Inc., Tulsa, USA) using the Chi<sup>2</sup> test, the Mann–Whitney *U*-test and the *t*-test.

## Results

No calcification was found in 8 ribs (6.6%), minor calcifications were found in 41 (34.2%) and major/complete calcification was found in 73 ribs (59.2%). Only in young patients no calcifications could be found (mean age 27.5 years). Persons with minor calcifications were younger than persons with severe calcification (mean age 58.1 years vs. 66.1 years), this was stistically significant ( $P < 0.001$ ). In total, there were 39 pseudarthrosis in 120 ribs (32.5%) (Figs. 2 and 3). In none of the ribs without calcification, pseudarthrosis could be seen. Only in three ribs with minor calcification a pseudarthrosis could be found (7.3%, 3/41). In contrast, in the 71 ribs with severe/complete calcification, 38 ribs showed pseudarthrosis (53%) (Fig. 2), i.e. the occurrence of pseudarthrosis was significantly higher in patients with severe and contiguous calcifications of the cartilaginous parts of the first rib (53%) in contrast to patients with no or minor calcification (6.1%;  $P < 0.001$ ). Pseudarthrosis was more common in men (40.6%) than in women (27.8%), but this difference was not statistically significant ( $P = 0.11$ ). No patient showed secondary signs of a fracture like hematoma or dislocation.

## Discussion

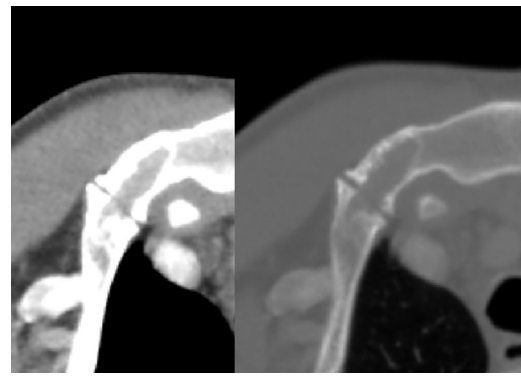
In our sample, a high prevalence of pseudarthrosis of the cartilaginous parts of the first ribs was noted in patients undergoing CT scanning of the chest for other reasons than trauma (32.5%). This is consistent with a study on anatomic specimen by Schils et al. [1]. They noted pseudarthrosis



**Figure 2.** Detail of a chest CT of a 60-year-old male patient undergoing staging for lung cancer. Calcification is more pronounced on the right side (grade 3) compared to the left side (grade 2). With progressive calcification, pseudarthrosis has occurred on the right side (arrow). Note the “cleft-like” appearance.

lateral to the sternocostal joint of the first rib in 37% of the cadavers (10 out of 27 specimen). In our sample, the occurrence of pseudarthrosis was significantly higher in patients with severe and contiguous calcifications of the cartilaginous parts of the first rib (53% vs. 6.1% in patients with no or minor calcification). This may be explained by the motion range of the shoulder girdle. The shoulder girdle is attached to the axial skeleton via the sternoclavicular joint, but there is the strong costoclavicular ligament connecting the proximal clavicle and cartilage of the first rib [4], i.e. the cartilaginous parts of the first rib and its synchondrosis seem to be also involved in proper functioning of the movement of the shoulder girdle. If, with severe calcification, flexibility of the cartilaginous parts is diminished, this may lead to pseudarthrosis formation to obtain the movement range. Like reported before, calcification progresses with age. But it should be kept in mind that severe calcifications may occasionally be noted in younger patients (Fig. 3). Pseudarthrosis was also more common in men; this may be explained by gender different levels of activity. Men may use the shoulder girdle longer or more often with subsequent pseudarthrosis formation.

The knowledge of the high prevalence of pseudarthrosis is important for physicians reporting CT scans of the shoulder girdle or the chest after trauma. In this study, pseudarthrosis was almost exclusively found in patients with severe calcifications. In the case of a patient undergoing imaging after trauma, a pseudarthrosis in a severe calcified cartilage of the first rib should be reported as an incidental finding unless other imaging or clinical (i.e. pain) findings are suggestive of fracture, i.e. accompanying haematoma or dislocation. The typical appearance of “osteophyte-like” articulating surfaces may also help to establish proper differential diagnosis. Pseudarthrosis of the first rib have been rarely reported to be symptomatic [5]. In cases with suspicion of a symptomatic pseudarthrosis of the cartilaginous parts, image-guided infiltration with local anaesthetics can be diagnostic and therapeutic [6]. When examining the first rib, radiologists should also be aware of congenital rib anomalies (like an accessory cervical ribs, hypoplastic ribs, forked ribs or bony bridges), which are reported to occur in up to 8% of patients undergoing imaging [7].



**Figure 3.** Detail of a chest CT in a 35-year-old patient undergoing imaging because of suspected empyema. There are marked ossifications of the cartilage of the first rib. Pseudarthrosis can be found lateral to the sternocostal joint. Note the “osteophyte-like” appearance of the articulating surfaces.

Limitations of this study are the relatively small sample size and the retrospective design. Only the clinical information of the requesting physician was available. Therefore, patients were not asked directly if there was recent trauma or if there was pain in the region of the first sternocostal joint, i.e. symptoms due to a pseudarthrosis may be overlooked in our sample. But the discrepancy of the high incidence of found pseudarthrosis in this study and the study by Schils et al. in contrast to the small number of case reports of symptomatic pseudarthrosis are suggesting limited clinical relevance of found pseudarthrosis of the first rib.

## Conclusion

With the progressive calcification of the cartilaginous parts of the first rib, pseudarthrosis are frequently found. These pseudarthrosis seem to be a common incidental finding that should not be mistaken for pathology in imaging after trauma.

## Disclosure of interest

The author declares that he has no conflicts of interest concerning this article.

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